CLAIMS

What is claimed is:

1. A hydrogen storage composition comprising:

$M'_xM''_yN_zH_d$

wherein

(a) M' is a cation selected from the group consisting of: Li, Ca, Na, Mg, K, Be, and mixtures thereof and x is greater than about 50 and less than about 53;

(b) M" comprises a cation composition comprising a Group 13 element of the Periodic Table and y is greater than about 5 and less than about 34;

(c) N is nitrogen and z is greater than about 16 and less than about 45;

(d) H is hydrogen and in a fully hydrogenated state, d is greater than about 110 and less than about 177; and

(e) wherein M', M", x, y, z, and d are selected so as to maintain electroneutrality.

2. The hydrogen storage composition according to claim 1 wherein hydrogen is released from the storage composition in a fully hydrogenated state to form a composition represented by the general formula $M'_xM''_yN_z$, where x is greater than about 50 and less than about 53; y is greater than about 5 and less than about 34; and z is greater than about 16 and less than about 45.

3. The hydrogen storage composition according to claim 1 wherein the storage composition is formed by reacting a hydride represented by the general formula $MI_a(MIIH_b)_c$ with a nitride represented by the general formula $MIII^f(NH_e)_g^{-c}$; and wherein a, b, c, e, f, and g are selected so as to maintain electroneutrality.

4. The hydrogen storage composition according to claim 3 wherein the storage composition is formed by a reaction between said hydride and said nitride, as represented by the reaction formula:

$A\,MI^a(MIIH_b)_a + B\,MIII^f(NH_e)_g^{-c} \rightarrow M'_x M''_y N_z H_d$ wherein M' comprises MI and MIII and M" comprises MII, wherein x is equal to (A+B), y is equal to a, z is equal to (B x g), and d is equal to ((A x a x b)+ (B x e x g)).

5. The hydrogen storage composition according to claim 4 wherein *A* is about 1 and *B* is from between about 0.5 to about 3.

6. The hydrogen storage composition according to claim 4 wherein *A* is about 1 and *B* is from between about 2 to about 2.25.

7. The hydrogen storage composition according to claim 4 wherein said nitride is lithium amide represented by the formula $LiNH_2$ and said hydride is lithium borohydride represented by the formula $LiBH_4$.

8. The hydrogen storage composition according to claim 4 wherein said nitride is lithium amide represented by the formula $LiNH_2$, said hydride is lithium aluminum hydride represented by the formula $LiAlH_4$.

9. The hydrogen storage composition according to claim 4 wherein the composition releases hydrogen by the following reaction:

$M'_x M''_y N_z H_d \rightarrow MI_A MII_{(Axa)} MIII_B N_{(Bxg)} + D\,H_2$ wherein M' comprises MI and MIII; M" comprises MII; $D = \left(\frac{d}{2}\right)$, and a, x, y, z, d, A and B are selected so as to maintain electroneutrality.

10. The hydrogen storage composition according to claim 1 wherein the hydrogen storage composition comprises a single phase.

11. The hydrogen storage composition according to claim 1 wherein the hydrogen storage composition is a compound.

12. The hydrogen storage composition according to claim 1 wherein the composition is expressed by the nominal general $Li_qB_rN_sH_t$ wherein the atomic ratio of q/r is about 3; s/r is about 2; and t/r is about 8.

13. The hydrogen storage composition according to claim 12 wherein the composition comprises $Li_3BN_2H_8$.

14. A method of storing hydrogen comprising: reacting a nitride having one or more cations other than hydrogen with a hydride having one or more cations other than hydrogen, wherein said reacting forms a hydrogen storage composition comprising hydrogen, nitrogen, and at least one of said one or more cations other than hydrogen derived from said nitride and derived from said hydride, respectively.

15. The method according to claim 14 wherein said hydrogen storage composition releases hydrogen by reacting to form a hydrogen product and one or more byproduct compositions comprising: nitrogen and at least one of said one or more cations other than hydrogen derived from said nitride and derived from said hydride, respectively.

16. The method according to Claim 14 wherein said hydride is represented by $MI^{a}(MIIH_{b})_{a}$, wherein MI represents a first cationic species other than hydrogen having an average valence state represented by a; MII represents a second cationic species other than hydrogen; and $\left(\frac{b x a}{1+a}\right)$ represents a ratio of hydrogen to cationic species present in the hydride.

17. The method according to Claims 16 wherein MI comprises a cation selected from the group consisting of: Li, Ca, Na, Mg, K, Be and mixtures thereof; and MII comprises a cation comprising a Group 13 element of the Periodic Table.

18. The method according to Claim 14 wherein said nitride is represented by $MIII^{f}(NH_e)_g^{-c}$, wherein MIII represents at least one cationic species other than hydrogen, f represents an average valence state of MI, $c=(3-e)$, $g=\frac{f}{c}$ and $\left(\frac{e\times g}{1+g}\right)$ represents an atomic ratio of hydrogen to cationic species present in said nitride.

19. The method according to Claims 18 wherein MIII comprises a cation selected from the group consisting of: Li, Ca, Na, Mg, K, Be, and mixtures thereof.

20. The method according to Claim 14 wherein said hydride is selected from the group of compounds consisting of: lithium hydride (LiH), lithium aluminum hydride ($LiAlH_4$), sodium borohydride ($NaBH_4$), lithium borohydride ($LiBH_4$), magnesium borohydride $Mg(BH_4)_2$, sodium aluminum hydride ($NaAlH_4$), and mixtures thereof.

21. The method according to Claim 14 wherein said nitride is selected from the group of compounds consisting of: lithium amide ($LiNH_2$), sodium amide ($NaNH_2$), magnesium amide ($Mg(NH_2)_2$), Li_3N (lithium nitride), magnesium imide (MgNH), borozane (BNH_6), lithium azide (LiN_3), and mixtures thereof.

22. The method according to Claim 14 wherein said nitride is lithium amide represented by the formula $LiNH_2$ and said hydride is lithium borohydride represented by the formula $LiBH_4$.

23. The method according to Claim 14 wherein said nitride is lithium amide represented by the formula $LiNH_2$, said hydride is lithium aluminum hydride represented by the formula $LiAlH_4$.

24. The method according to Claim 14 wherein said reacting is conducted in an inert atmosphere.

25. The method according to Claim 14 wherein prior to said reacting, reducing said nitride to an average particle diameter size of less than about 3 μm.

26. The method according to Claim 14 wherein prior to said reacting, reducing said hydride to an average particle diameter size of less than about 25 μm.

27. The method according to Claim 14 wherein said reacting is conducted at a temperature of about 85°C or greater.

28. The method according to Claim 14 wherein said reacting is conducted in a milling process, wherein said nitride and said hydride are milled to reduce particle size and provide energy sufficient for said reacting of said nitride with said hydride.

29. A method of releasing hydrogen comprising: reacting a hydrogen storage nitride composition having one or more cations other than hydrogen with a hydrogen storage hydride composition having one or more cations other than hydrogen, wherein said reacting releases hydrogen and forms one or more byproduct compounds comprising: nitrogen and at least one of said one or more cations other than hydrogen derived from said nitride composition and from said hydride composition, respectively.

30. The method according to Claim 29 wherein said hydride composition is represented by $MI^{a}(MIIH_{b})_{a}$, wherein MI represents a first cationic species other than hydrogen having an average valence state represented by a, MII represents a second cationic species other than hydrogen, and $\left(\frac{b x a}{1+a}\right)$ represents an atomic ratio of hydrogen present to cationic species in said hydride composition.

31. The method according to Claim 29 wherein said nitride composition is represented by $MIII^{f}(NH_{e})_{g}^{-c}$, wherein MIII represents at least one cationic

species other than hydrogen, f represents an average valence state of MI, $c = (3 - e)$, $g = \frac{f}{c}$ and $\left(\frac{e \times g}{1+g}\right)$ represents an atomic ratio of hydrogen to cationic species present in said nitride composition.

32. The method according to Claim 30 or 31 wherein said MI, MII, and MII are each cations independently selected from the group consisting of: CH_3, Al, As, B, Ba, Be, Ca, Cd, Ce, Cs, Cu, Eu, Fe, Ga, Gd, Ge, Hf, Hg, In, K, La, Li, Mg, Mn, Na, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Si, Sm, Sn, Sr, Th, Ti, Tl, W, Y, Yb, Zn, Zr, and mixtures thereof.

33. The method according to Claim 30 or 31 wherein MI or MIII comprises an element selected from the group consisting of: Al, B, Li, Na, K, Be, Mg, Ca, Sr, and mixtures thereof.

34. The method according to Claim 30 wherein MI is selected from the group consisting of: Al, B, Ca, Li, Mg, Na and mixtures thereof.

35. The method according to Claim 30 wherein MII comprises an element independently selected from the group consisting of: Al, B, Ca, Li, Na, Mg and mixtures thereof.

36. The method according to Claim 30 wherein said hydride composition is selected from the group of compositions consisting of: lithium

hydride (LiH), lithium aluminum hydride ($LiAlH_4$), sodium borohydride ($NaBH_4$), lithium borohydride ($LiBH_4$), magnesium borohydride $Mg(BH_4)_2$, sodium aluminum hydride ($NaAlH_4$), and mixtures thereof.

37. The method according to Claim 29 wherein said nitride composition is selected from the group of compositions consisting of: lithium amide ($LiNH_2$), sodium amide ($NaNH_2$), magnesium amide ($Mg(NH_2)_2$), Li_3N (lithium nitride), magnesium imide (MgNH), borozane (BNH_6), lithium azide (LiN_3), and mixtures thereof.

38. The method according to Claim 29 wherein said nitride composition is lithium amide ($LiNH_2$) and said hydride composition is lithium borohydride ($LiBH_4$).

39. The method according to Claim 29 wherein said nitride composition is lithium amide ($LiNH_2$) and said hydride composition is lithium aluminum hydride ($LiAlH_4$).

40. The method according to Claim 29 wherein said reacting is represented by the general formula $A\,MI^{a}(MIIH_{b})_{a} + B\,MIII^{f}(NH_{e})_{g}^{-c} \longrightarrow MI_{A}MII_{(A\times a)}MIII_{B}N_{(B\times g)} + D\,H_{2}$, where

$c = (3 - e)$, $D = \frac{(A \times a \times b) + (B \times e \times g)}{2}$, and $g = \frac{f}{c}$, and a, b, c, e, f, g, A and B, are selected so as to maintain electroneutrality.

41. The method according to Claim 40 wherein said MI, MII, or MIII is selected from the group consisting of: CH_3, Al, As, B, Ba, Be, Ca, Cd, Ce, Cs, Cu, Eu, Fe, Ga, Gd, Ge, Hf, Hg, In, K, La, Li, Mg, Mn, Na, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Si, Sm, Sn, Sr, Th, Ti, Tl, W, Y, Yb, Zn, Zr, and mixtures thereof.

42. The method according to Claim 40, wherein said reacting is represented by the general formula

$$A\,MI^{a}(MIIH_{b})_{a} + B\,MI^{f}(NH_{e})_{g}^{-c} + E\,MIIIIH_{h} \longrightarrow MI_{A}MII_{(A\times a)}MIII_{B}MIIII_{E}N_{(B\times g)} + D\,H_{2}$$

wherein a third composition $MIIIIH_h$ is present as a reactant and $c = (3 - e)$, $D = \frac{(A \times a \times b) + (B \times e \times g) + (E \times h)}{2}$, and $g = \frac{f}{c}$ and a, b, c, e, f, g, h, A, B, and E are selected so as to maintain electroneutrality.

43. The method according to Claim 42 wherein MIIII of said third composition represents a cationic species other than hydrogen and h represents an atomic ratio of hydrogen in said third composition, wherein h is from 0 to about 2.

44. The method of Claim 42 wherein said third composition is selected from the group consisting of: MgH_2, Mg, and mixtures thereof.

45. The method according to Claim 29 wherein said reacting is conducted in an inert atmosphere.

46. The method according to Claim 29 wherein prior to said reacting, reducing said nitride composition to an average particle diameter size of less than about 3 μm.

47. The method according to Claim 29 wherein prior to said reacting, reducing said hydride composition to an average particle diameter size of less than about 25 μm.

48. The method according to Claim 29 wherein prior to said reacting, reducing said nitride composition and said hydride composition to an average particle diameter size of less than about 15 μm.

49. The method according to Claim 29 wherein said reacting is conducted at a temperature of at least about 85°C.

50. The method according to Claim 29 wherein said reacting is conducted in a milling process, wherein said nitride composition and said hydride composition are milled to reduce particle size and generate energy sufficient to facilitate said reacting of said nitride composition with said hydride composition.

51. The method according to Claim 29 wherein said reacting to release hydrogen is conducted at about 170°C or greater.

52. The method according to Claim 29 wherein said reacting to release hydrogen is conducted at about 210°C or greater.